

Implementation of Computer-Based Patient Records in Primary Care: The Societal Health Economic Effects

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Objective -- Exploration of the societal health economic effects occurring during the first year after implementation of Computerised Patient Records (CPRs) at Primary Health Care (PHC) centres.

Design -- Comparative case studies of practice processes and their consequences one year after CPR implementation, using the constant comparison method. Application of transaction-cost analyses at a societal level on the results.

Setting -- Two urban PHC centres under a managed care contract in Östergötland county, Sweden.

Main outcome measures -- Central implementation issues. First-year societal direct normal costs, direct unexpected costs, and indirect costs. Societal benefits.

Results -- The total societal effect of the CPR implementation was a cost of nearly 250,000 SEK (USD 37,000) per GP team. About 20% of the effect consisted of direct unexpected costs, accrued from the reduction of practitioners' leisure time. The main issues in the implementation process were medical informatics knowledge and computer skills, adaptation of the human-computer interaction design to practice routines, and information access through the CPR.

Conclusions -- The societal costs exceed the benefits during the first year after CPR implementation at the observed PHC centres. Early investments in requirements engineering and staff training may increase the efficiency. Exploitation of the CPR for disease prevention and clinical quality improvement is necessary to defend the investment in societal terms. The exact calculation of societal costs requires further analysis of the affected groups' willingness to pay.

INTRODUCTION

Research on computer applications in clinical environments has ranged from high-level design of integrated hospital information systems¹ to evaluations of computer-based patient record (CPR) systems in use.² However, few studies have investigated the process by which information systems are implemented in a clinical environment.

The research has mainly been conducted in hospital environments, and only exceptionally in primary health care (PHC) settings.³

The transaction-cost theory^{4,5} addresses the economic consequences the organisation of work flow has for an enterprise. According to the theory, every enterprise strives to use its human and economic resources to achieve an optimal production capacity. For instance, in health care, all kinds of administrative work prevent practitioners from being able to provide the patient health services. Further, according to the theory efficiency depends on the use and choice of procedures. Since transactions free of costs do not exist, the management of these inevitably has consequences for resource allocation in a health care organisation. The aim of this study is to analyse the CPR implementation process in PHC to indicate its short-term and long-term economic consequences at a societal level. In particular, case study methods and the transaction-cost theory are used to identify and analyse the impacts.

METHODS

Comparative case studies⁶ were conducted at two urban PHC centres implementing CPRs. Each centre employed about 50 staff, including 6-8 GPs. As a baseline, observation by "shadowing" a PHC team was performed at one of the centres before the implementation to establish a general model of the work flow in PHC. The CPRs investigated in the study were supplied by different manufacturers and designed for use in primary care. The systems supported full-text patient records, a controlled medical terminology, a structured patient database, and tools for the analysis and reporting of patient data. Both implementations were based on a client-server architecture. The hardware at the sites comprised one server supporting approximately 40 workstations and 20 printers.

One year after the centres started using CPRs, observations and interviews were conducted at both sites. Representatives from all professional categories using the CPR were used as informants (10 GPs, 12 nurses, 3 nurses' aides, 5 secretaries, 3 physiotherapists, 1 dietician, and 2 occupational therapists). Work place observations were conducted by researchers acting as observers, who asked occasional questions when needed. The interviews were semi-structured and took place in the practice setting. Open-ended questions were used to obtain

information about what the underlying causes were of the phenomena observed. Both observations and interviews were recorded in fieldnotes. The constant comparison method⁷ was employed for analysing and structuring the data. Only issues identified at both sites were used to build inductively a local theory. A cost-consequence analysis, adjusted from a traditional cost-benefit analysis,⁸ was, consequently, applied to calculate the true costs related to the CPR implementation. Direct cost and indirect cost were separated. To estimate the value of the costs, the opportunity cost principle⁹ was used, i.e., the value of the forgone benefits due to the resource not being available for its best alternative use. The indirect costs compromise the value of goods and services which could have been produced under normal circumstances. Average unexpected costs were estimated on the basis of the medical staff time costs. For equipment depreciation over time, a 5-year straight-line depreciation was assumed at a 4% discount rate. "Normal activities" were defined as all other activities apart from the labour market. The quantification of these activities comprises loss on production at home and loss in utility when recreational activities are discontinued. The same value for normal activities was used for all individuals (72 SEK/hour). All quantifiable costs were calculated at 1995 years prices. Shared or overhead costs, for example floor space, were not calculated because they did not change with the CPR implementation. Human costs in terms of pain and suffering were left as qualitative findings. Only the cross-validated issues from the local theory were included in these calculations. Finally, a sensitivity analysis was performed to study the impact of the cost and benefit estimations of these calculations.

RESULTS

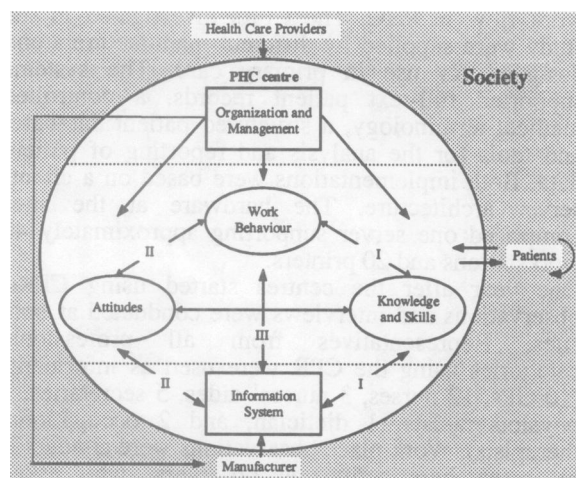


Figure 1 - Main structural and process components of primary care delivery

The qualitative and quantitative analysis resulted in three main issues (Figure 1):

- I. Medical informatics: knowledge and skills
- II. Human-computer interaction (HCI) design
- III. Availability of complete patient data

The management at both PHC centres were satisfied with the CPR implementation. The first-year economic effect of the implementation of CPRs in PHC was extra costs of approximately 2.0MSEK (300,000USD) (Table 1). The cost for an average GP team was nearly 250,000SEK (37,000USD). The unexpected costs were approximately eight times higher than the costs spent on training.

Table 1 - Summary of the first-year economic effects of the CPR implementation

Category 1: Direct costs	SEK
Training	54,000
Hardware and software (Net present value)	1,471,700
Project manager system supplier	6,700
Maintenance	109,700
Total direct costs	1,642,100
Category 2: Unexpected costs	SEK
Self-training during working hours	109,100
Loss of normal activities in leisure hours	69,100
Increase in administrative work load	192,000
Extra service	3,300
Summarising medical records	77,400
Total unexpected costs	450,900
Category 3: Indirect costs (Unquantified costs)	
Patient:	
• Extra waiting time	
• Discomfort for extra waiting time	
• Suffering of patients not admitted	
Staff:	
• Stress, irritation, and frustration	
Society:	
• Decrease in labour market productivity since the patients are not attended to (i.e. they stay at home)	
Category 4: Benefits	SEK
Time saved due to less need to fetch paper-based medical records	72,900
• Increase in knowledge capital for PHC team	
• Easier and quicker communication for GPs during telephone consultations	
• Clearer information to patients	
TOTAL (Quantifiable effects)	-2,020,100

Implementation Issues

The implementation issues below are broken down into processes observed, consequences, and economic effects.

I. Medical informatics: knowledge and skills

Processes observed: Many users lacked specific knowledge for using central functions. General knowledge of informatics and computer technology was virtually non-existent. The lack of knowledge and skills, as a consequence of the non-optimal education given, forced the users to acquire knowledge through trial and error during ordinary working hours. Some users even tried to get help

from family and relatives. Further, when they found themselves incapable of handling a situation related to the CPR, they asked each other and the local CPR co-ordinator (a departmental manager and physiotherapist). Therefore, the co-ordinator experienced an unmanageable increase in workload. **Consequences and economic effects:** The knowledge for using the CPR was found to be too superficial. Unexpected costs for training during working hours affected the budget of the PHC centre in the form of an immediate decrease in resources. At the same time the practitioners also became subject to increasing costs due to a decrease in available time for normal activities in leisure hours. Moreover, inefficient use of the CPR caused longer patient waiting time and therefore caused discomfort. Additionally, time was lost when staff needed to learn to use the CPR without supervision (Table 2).

Table 2 - First-year economic consequences related to knowledge and skills

Direct costs (SEK)	
Fixed costs:	
Training of CPR co-ordinator (3 days/ind, 2 ind, SEK3,600/ind)	7,200
General training (1 day/ind, 39 ind, SEK1,200/ind)	46,800
Total cost of education	54,000
Variable costs:	
Self-training (30 min/week, 48 weeks)	
• GPs (8 ind, SEK5,280/ind)	42,200
• Nurses (19 ind, SEK2,256/ind)	42,900
• Nurses' aides (4 ind, SEK1,968/ind)	7,900
• Secretaries (5 ind, SEK2,367/ind)	9,400
• Occupational therapist	2,200
• Dietician	2,200
• Physiotherapist	2,300
Total cost of self-training	109,100
Loss of normal activities in leisure hours (1 hour/week, 48 weeks, 20 ind)	69,100
Total direct costs	232,200
Indirect costs	
Patient:	Staff:
• Extra waiting time	• Uncertainty and stress due to lack of knowledge
• Discomfort due to extra waiting time	
Benefits	
• Increase in knowledge capital for PHC personnel	
Total (Quantifiable effects)	-232,200

Differences between the factual and an optimal knowledge level of the practitioners caused unexpected costs. Daily inefficient use of functions slowed down the work pace, and the feeling of not being able to handle the CPR created stress and a fear of making mistakes. Consequently, an increase in the medical informatics knowledge of the practitioners can be assumed to raise productivity as a consequence of higher utility of functions.¹⁰

II. Human-computer interaction design

Processes observed: Due to the non-optimal design of HCI functions, the clinical work of the staff was often obstructed. Many of the staff felt that the system design was not adjusted to fit the work flow, i.e. the CPR forced them to adjust their behaviour to fit its functions. Therefore, they regarded the CPR as a hindrance in their daily work.

Frustration and irritation also piled up when the CPR was not available during frequent system shut-downs.

Consequences and economic effects: The non-optimal system design caused an unwillingness to adapt to the organisational changes that the computerisation required, and a reluctance to use the system. This became even more evident in the light of the time strain for the PHC centre staff. When things were at worst, some practitioners even turned off their computers, refusing to use them. Others did not use functions they knew were not working appropriately or otherwise did not fulfil their needs. To deal with the situation, the practitioners reduced their service production (they attended to one to two fewer patients per day) and/or took work home (Table 3).

Table 3 - First-year economic consequences related to a non-optimal HCI design

Direct costs (SEK)	
Variable costs:	
Increase in administrative work load (5 admittance fees/week, SEK100/admittance fee, 48 weeks, 8 GPs)	192,000
Indirect costs	
Staff:	Patient:
• Stress, frustration, and irritation	• Suffering of patients not admitted
Society:	
• Decrease in productivity (5 pat/week, 8 GPs, 48 weeks = 1,920 adults/ year)	
Total (Quantifiable effects)	-192,000

The increase in administrative work load directly affected the economy of the PHC centres, since it reduced the number of attended patients (estimated to be 240 patients/year/GP). Additionally, it caused stress and frustration for the staff. Patients were affected by not being admitted to the PHC centres. In the longer perspective there will be a decrease in production in both the labour market and non-labour market.

III. Availability of complete patient data

Processes observed: Data stored in the CPR was easily accessed by all authorised staff members. Immediate access to this data made it easier for the GPs to provide instant answers to patients during telephone consultations. Moreover, summarised medical histories, diagnoses, contacts with PHC personnel, and treatments performed were available to all practitioners and enabled them to get rapid overviews. It was also easier to renew prescriptions,

since these were already stored in the CPR. To be able to have all information about the patient in the CPR, GPs had to summarise the paper-based medical records. This was done by dictations, which were submitted to the secretaries for transfer to the CPR. Further, since all medical data could not be stored in the CPR systems (e.g. ECG charts and radiographs) of today, the PHC centres had to maintain a paper-based medical record parallel to the CPR. Those practitioners who maintained parallel filing systems were the least affected when the CPR repeatedly went down.

Consequences and economic effects: The implementation of a CPR involved both extra economic consequences and individual efforts. On the other hand, the GPs claimed that only the CPR had made efficient patient-doctor telephone consultations possible. Further, time was saved due to the ease of renewing prescriptions. These were easier to read for the patient than hand-written prescriptions. Some of the patients took greater interest in the CPR when compared to the paper-based medical record and, thus, more actively sought information (Table 4).

Table 4 - First-year economic consequences related to availability of information

Direct costs (SEK)	
Fixed costs:	
Hardware and software (Net present value)	1,471,700
Project manager system supplier	6,700
Maintenance	109,700
Variable costs:	
Need for extra service of IT	3,300
(SEK550/service occasion, 6 occasions)	
Summarising medical records (MRs) Only 75 records (5%) are summarised per GP, 8 GPs	77,400
[GPs (30 min/MR): SEK110/MR Secretaries (15 min/MR): SEK19/MR Cost per patient record = SEK129]	
Total costs	1,668,800
Benefits (SEK)	
Time saved due to less need for fetching the paper-based medical record (0,5 nurses' aide)	72,900
<ul style="list-style-type: none"> Easier and quicker communication for GPs during telephone consultations Clearer information to patients 	
Total (Quantifiable effects)	-1,595,900

The first-year costs of the CPR implementation were high due to the necessary investments in hardware and software. Moreover, the CPR brought about transitional work elements, e.g. summarisation of medical records. However, the costs caused by these new work elements will decrease over time. Thus, it seems that the benefits of the availability of the patient data will be greater than the costs in the long run, provided the maintenance costs do not increase too much at the same time.

Sensitivity analysis

Using the data on costs and benefits as the basis, the sensitivity analysis reflects the impact of variations in the quantified costs and benefits. Only the quantifiable costs and benefits were included in the calculations (Table 5). For each impact rate the following variations were made:

1. A reduction in costs by 50% and an increase in benefits by 100%.
2. A reduction in costs by 25% and an increase in benefits by 100%.
3. A reduction in costs by 10% and an increase in benefits by 100%.

For all impact rates and variations, the net present value of the economic appraisal remains negative. Consequently, the result of the cost-consequence analysis shows little sensitivity to variation in the level of costs incurred in the first year of the implementation. The benefits of the CPR implementation are clearly smaller than the costs generated.

Table 5 - Results of sensitivity analysis

Appraisal	Impact rate (%) and variations			Original appraisal
	50%	25%	10%	
Direct costs	821,000	1,231,600	1,477,900	1,642,100
Unexpected costs	225,400	338,200	405,800	450,900
Indirect costs	-	-	-	-
Benefits	145,800	145,800	145,800	72,900
Net present value	-900,600	-1,424,000	-1,737,900	-2,020,100

DISCUSSION

The results show that the societal costs exceed the benefits during the first year after the implementation of CPRs. Hence, to defend the investment in societal terms, later exploitation of the CPRs in PHC for, e.g., disease prevention¹¹ and clinical quality improvement is necessary.¹² Economic evaluations of information system implementations in health care have been reported to be methodologically difficult, even though these have mainly been restricted to effects at the unit level.¹³ Only more recent studies have included effects on the external environment, but so far these have used simulated data.¹⁴

Our analysis at the societal level, based on empirical data, indicated that costs were accrued due to lack of the training in using the CPR and by non-optimal system design. These findings should be used as a basis for change in policy decisions regarding CPR implementations. Before more of the scarce resources for health care are invested in CPRs, it is necessary to consider that the objective of PHC centres is to produce the care demanded by patients to increase their health and to reduce the time lost from social activities due to illness. Rational decision-making at the PHC management level does not automatically provide effectiveness at the societal level. Since in managed care a CPR is often

paid for from a monetary source different from the normal budget of the care unit, many unnecessary negative effects may be accepted. Furthermore, in this study only the training and maintenance were paid by the PHC centres, which can explain why the low first-year benefits were considered acceptable. Most costs and negative effects from the implementation were paid instead by individuals or the society at an aggregate level. Hence at the societal level, more investments in requirements engineering and staff training might provide a higher long-term efficiency.

When considering the results, it has to be recognised that not all potential costs and benefits have been quantified. The study has also been explorative in trying to evaluate the social, technical, and economic factors involved in CPR implementation. The approach used to assess these factors is essentially a pragmatic one. Where costs or benefits can be estimated with reasonable objectivity, this has been done, whereas, in other cases, the existence of the costs or benefits has merely been noted. The sensitivity analysis made possible some reflections over these deficiencies. However, it showed that the results were robust enough to draw the cautionary conclusions.

It is important to emphasise the difficulty of evaluating expected profits in making policy decisions. New technologies are used by physicians at PHC centres also to increase the quality of medical care and not only its efficacy. The apparent inconsistency may thus be explained by the fact that the introduction of new technology represents a form of social investment by the acquisition of knowledge, which can improve the effectiveness of the health care delivery system in the long run,¹⁵ e.g. a decrease in repeated lab studies and unnecessary hospital admissions due to better access to patient data. One way of assessing whether the CPR implementation project will be economically profitable to society in the long run is to use the Kaldor-Hicks criteria,¹⁶ where the affected groups' willingness to pay is measured. However, that would require further studies.

In conclusion, a part of the negative first-year societal effects may have accrued due to the nature of the monetary flows between the stake-holders in the implementation process. Even though it is almost a truism, it is necessary to consider that a health organisation is run by people for people. This seems to have been overlooked by the policy-makers in the case of CPR implementation, since the individual practitioners and patients seem to have been made victims of erroneous or non-optimal use of scarce resources.

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